Empa News

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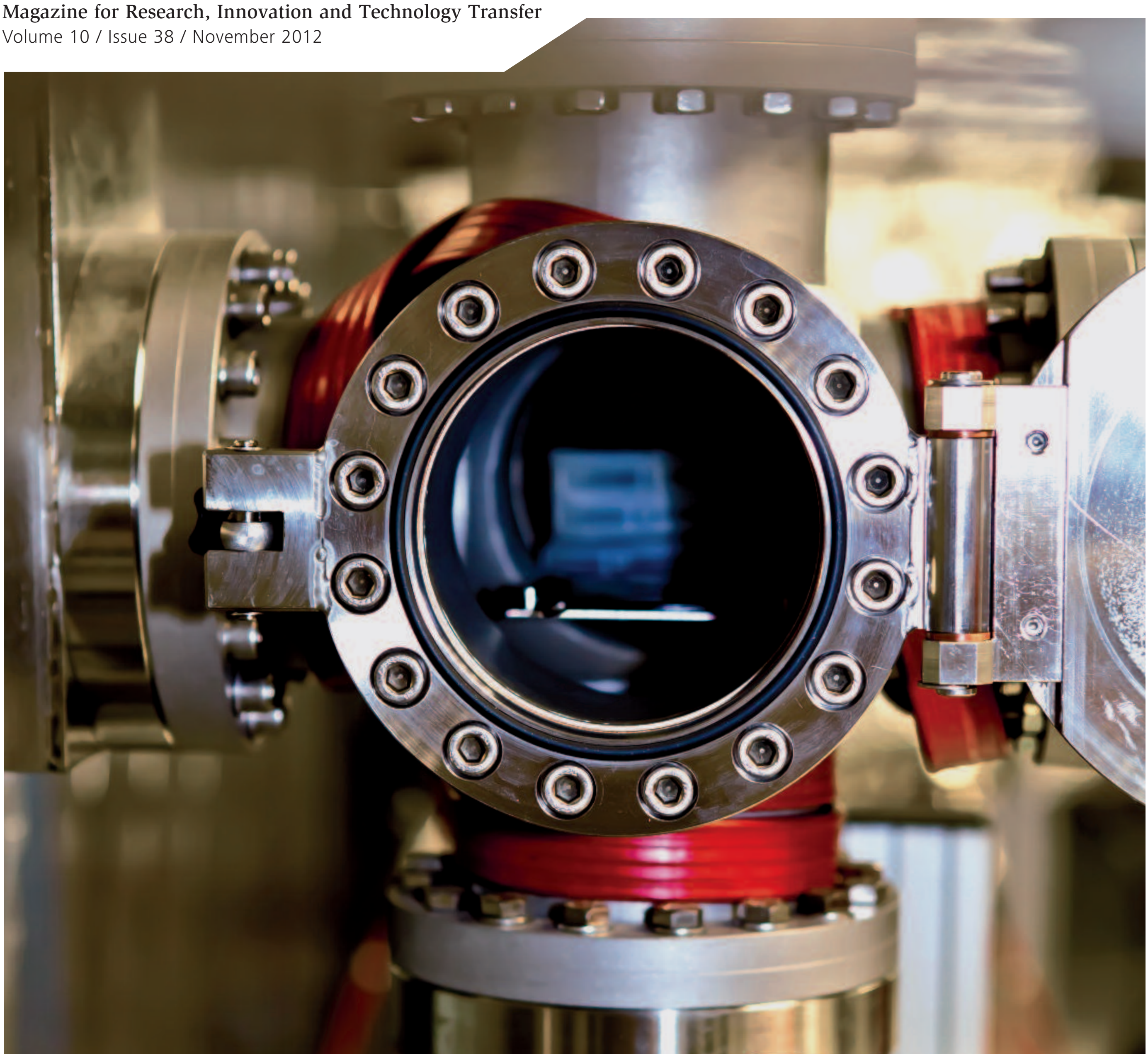
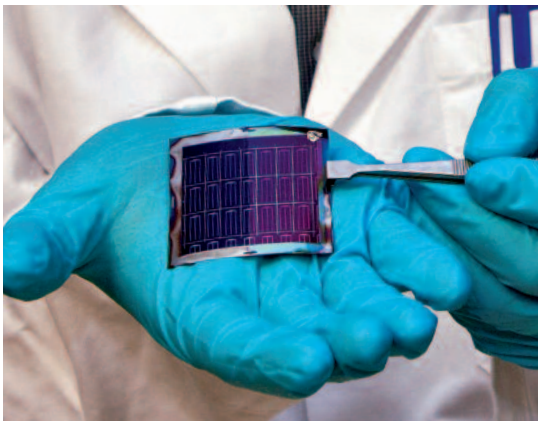


Solar energy supply

EMPA
Materials Science & Technology



Inorganic solar cells
Thin layers on the way to serial production 04

Switzerland's Energy Turnaround

Looks as though our energy system is facing a radical redesign. This was sketched out by the Swiss government in its "2050 Energy Strategy", and initial measures have already been implemented. At its core it's all about consuming less "classical" energy and making more use of renewable energy sources.

When you take a closer look, however, at what looks rather straightforward on paper, it turns out to be a hugely complex endeavour – with erstwhile "bearers of hope" frequently and suddenly becoming the "bad guys". One example of this is biogenic fuels, the majority of which are anything but "bio" (see page 20). Or take the mobility area where, after the initial e-mobility hype, the pendulum is slowly swinging in the opposite direction.

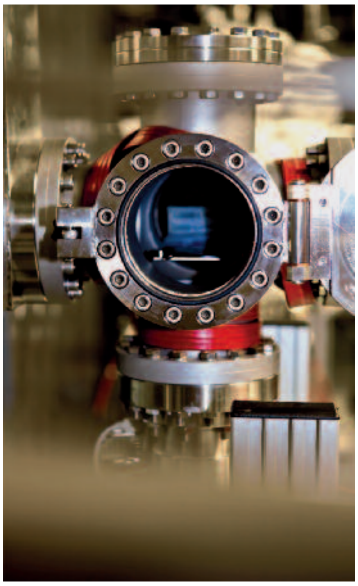
What can we (hopefully) learn from this? First and foremost, that there is no simple panacea in energy matters. If we wish to accomplish the energy turnaround, the last thing we want to do is pit the different approaches against each other. On the contrary, we should also be thoroughly scrutinizing and considering the weaknesses of future energy sources and systems. We would thus be capable of drawing up a scenario that would exploit the strength of each and every energy source to its fullest potential.

This will entail, among other things, a considerable amount of diversification in the mobility sector. Instead of only relying on fuels based on oil, different energy sources will help transport people and goods in the future. An insight into how this might work is provided by "CLEVER", a vehicle developed at Empa that combines an energy-saving hybrid drive with a low-CO_2 natural gas engine (see page 10).

Sounding out the pros and cons of the different mobility types and developing them further is also the goal of the "Future Mobility" demonstrator we are currently designing (see page 16). This is Empa's contribution to objectifying current energy discussions, in which emotions often run high.

Enjoy reading the current issue of EmpaNews!

Michael Hagmann
Head Communications



Cover

The solar cell of the future is being created inside this vacuum evaporation system: The active layer made from copper, indium, gallium and selenium is 100 times thinner than that of a silicon solar cell. This makes the cells cheaper – and also flexible.

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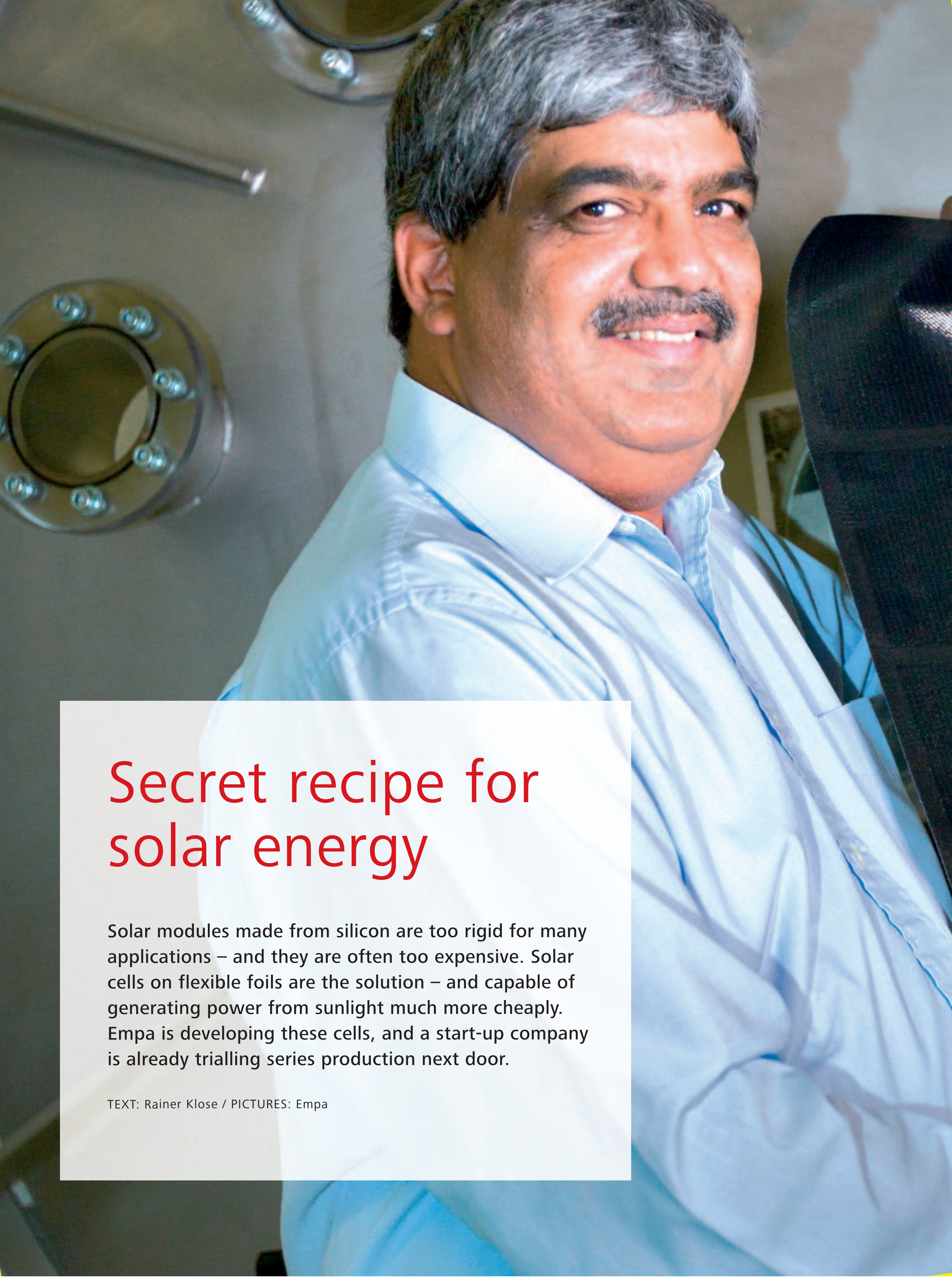

Secret recipe for solar energy

Solar modules made from silicon are too rigid for many applications – and they are often too expensive. Solar cells on flexible foils are the solution – and capable of generating power from sunlight much more cheaply. Empa is developing these cells, and a start-up company is already trialling series production next door.

TEXT: Rainer Klose / PICTURES: Empa

Empa solar researcher Ayodhya Tiwari is also a start-up entrepreneur. Extremely large, flexible thin-film solar cells can be manufactured in his company's large vacuum evaporation systems. At the same time, Tiwari is continuing to investigate the principles of the technology with his research group at Empa.

Some rooms at Empa are no-go areas for dust from outside. The research laboratory of Ayodhya Tiwari and his team is one of these places. You have to stop before entering: blue plastic overshoes are a must, and are donned at the laboratory entrance. The subject of the research is the reason for the low-dust and crumb-free atmosphere: solar cells with an active coating that is a mere 1/500 th of a millimetre thick. In spite of this, these so-called thin-film cells are capable of converting 20 percent of sunlight into electricity.

In just a few years we might encounter these thin-film cells everywhere – on car roofs and outdoor clothing, on solar roller blinds or roofing felt from the DIY store – and above all in gigantic solar arrays. In other words, anywhere where silicon cells are too rigid and inflexible, and also in places where silicon technology is not yet financially viable. The technical reason for this is simple: Crystalline silicon has to be about a fifth of a millimetre thick in order to be used in a solar cell. However, it cannot be bent, since the crystal would break. The high coating thickness also uses up a lot of material, which eats into the budget.

The advantage of thin-film cells

These problems are avoided with thin-film cells, which have a coating that is 100 times thinner However, they are tricky to manufacture, particularly because the cells need to be extremely effi-

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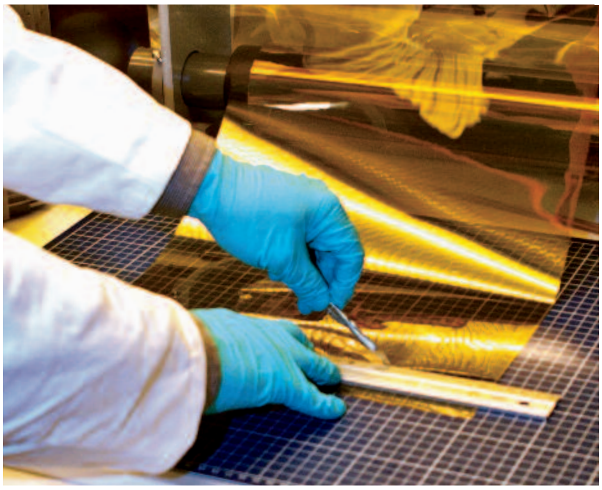
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cient. Tiwari's team is involved in researching CIGS cells – the abbreviation stands for "Cooper Indium Gallium (di-)Selenide". Part of the team fabricates the cells from a solution using a wet chemical process. The application of dissolved substances is technically simpler, but only produces cells with low efficiency.

Another part of the research team is investigating evaporation behaviour for manufacturing CIGS cells. Last year the Empa team succeeded in breaking the efficiency record for flexible solar cells made from plastic film using this method: The Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany, confirmed an energy yield of 18.7 percent.

We are now standing with our overshoes on next to several steel vacuum evaporation systems in which the record-breaking cells were prepared. Group leader Stephan Bücheler explains the complexity of the manufacturing process: the basis for the cells is a film made from polyamide – a high temperature-resistant plastic that has to withstand the procedure that follows. A layer of molybdenum is first applied using the sputter procedure. The metallised film then passes through several locks into the high vacuum evaporation system. "This is where a decisive stage of manufacture occurs", says Bücheler. "The CIGS layer consisting of the "ingredients" copper, indium, gallium and selenium is applied by means of evaporation. The composition is not the same over the entire coating thickness, but varies from top to bottom".

Secret recipe

The CIGS-coated film is then removed from the vacuum, a buffer coating is applied using a wet chemical method, then a top coat of zinc oxide is applied, which also acts as an electrode. This is done by sputtering. The decisive know-how, however, is in the CIGS layer: The Empa researchers manually control the temperature of the individual ingredients, and therefore their evaporation speeds. A coating with a gradually differing composition forms on the film. The basic principle may be widely known, but the fine details of the process are secret. The oldest evaporation system has already been in operation for 20 years. The Tiwari team has been experimenting on the perfect CIGS cell for just as long. Of course, experimentation does not mean "trial and error" until the mixture is right. The theoretical principles behind the perfect cell have to be worked out, and the effects and results that occur have to be discussed within the scientific community. A balanced strategy is required between publishing a result or protecting it by means of a patent.

The long road to series production

However, one of the most complicated and expensive steps is the road from the laboratory to series production. Because even with the best research results, you can only feed energy into the power grid if the product that you are looking for is available in sufficient quantities. "This step requires a large team, many months (if not years) of work, and a great deal of money", stresses Ayodhya Tiwari. He established the start-up company "Flisom" together with several of his previous Ph.D students and rounded up several investors. Whereas test cells that are five square centimetres in size are produced in the laboratory, series production of large cells is carried out at Flisom. The research company's site is just a few hundred metres away from the laboratory, situated also on the Empa campus.

Behind a plain steel door, visitors have to put plastic overshoes over their street shoes again, because prototype production is also tricky. Tiwari guides us through the building in which some 20 employees are working meticulously on the series production of flexible thin-film cells. Everything already looks extremely industrial here: Large, cylindrical machines are standing around,

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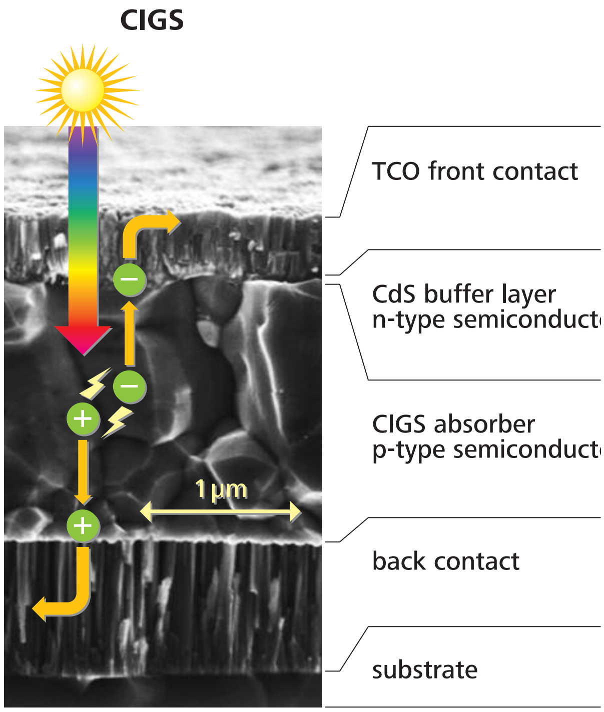


each of which is about four metres in diameter. This is where the coating procedure is going to take place, in a high vacuum. The prepared polyamide film to which a molybdenum coating has already been applied is clamped on a large spindle inside of the cylinder, then the air is pumped out of the system. The film is then unrolled, coated with the CIGS coating, then rolled up again, while still being inside the vacuum. The subsequent coating steps then take place outside the machine.

"Tough competition"

So much for the principle. One of the machines is currently open for maintenance work and gives us the chance to have a peek inside. A complicated system consisting of spindles, guide rollers and metal boxes. "You are not allowed to take photographs", says Tiwari and holds back our camera-toting colleague. Everything is strictly confidential: "There is a lot of tough international competition in this area". The large film coating systems are technically related to the machines that are already used in the packaging industry. An industrial equipper delivers custom-made machines to Flisom. "However, not even the supplier knows all of the details", smiles Tiwari. "We order the systems with certain gaps in the housing. Only we know what is installed in these areas".

We asked the Empa researchers when the first CIGS systems would be on the market. "We are almost ready for series production", replies Tiwari. From the sound of things, if everything goes well the production method will be ready for market in less than five years. Prototypes of CIGS cells are already on the roof at Empa and are being tested for their durability in wind and weather, in summer and winter. The first solar farms based on low-cost thin-film cells could be up and running in five to ten years. The long journey from laboratory research to energy production will then be finished. //

1
A heat-resistant special film made from polyimide plastic forms the flexible basis for CIGS thin-film cells.

2
Group leader Stephan Bücheler removes one of the thin-film cells from the laboratory evaporation system. A mixture of copper, indium, gallium and selenium is evaporated onto the carrier film in a high vacuum – hence the abbreviation CIGS.

3
The individual layers of a CIGS cell and its manufacturing method. The active layer is 100 times thinner than that of a conventional silicon cell. This saves money and resources.

EU funding

Empa and the start-up company Flisom are partners in the European R2R-CIGS Consortium, which has set itself the target of promoting the development of high-efficiency CIGS Solar modules on flexible substrates. The European Commission is sponsoring the R2R-CIGS research and development project to the tune of 7 million Euros.

The energy that comes from dyes

Frank Nüesch would like to contribute to the energy revolution with the aid of low-cost solar cells made from organic dyes. Advantage: The cells can also be transparent, making them suitable for office glazing and car windows.

TEXT: Rainer Klose / PICTURES: Empa

The way in which a solar cell captures light and converts it into energy is not easy to explain. A visit to Frank Nüesch therefore quickly becomes an intellectual "tour de force" through the world of quantum chemistry. The physicist manages the "Functional Polymers" laboratory and conducts research into solar cells on the basis of organic chemistry, the idea being for light to be "converted to electricity" with the aid of carbon compounds. In order to achieve this, in-depth knowledge of semiconductor physics is equally as important as virtuosity in the chemical synthesis lab.

To put it simply, an organic solar cell works like this: Light falls onto a dye and stimulates oscillation in electrons. The oscillating electrons can transmit their energy from one molecule to another, until they are eventually collected by an acceptor molecule and passed to an electrode. The "lost" electrons are returned to the dye by the counter electrode. The result is a flow of electricity that has been triggered by light.

A fledgling discipline

Organic solar cells are very much a new scientific discipline. The first one was constructed by Ching W. Tang in the Kodak Research Laboratories in 1986 – which was still 33 years after the first silicon solar cell, which originated in the laboratories of US telephone company Bell. However, the race to catch up in the laboratories of the world has been going on since the 1990's: The first organic cells achieved an efficiency level of more than 10 percent, meaning that they achieved the performance of amorphous silicon cells. "It is only a matter of time before organic solar cells come onto the market", says Nüesch.

A series of advantages leads us to believe that they will also assert themselves in competition with the silicon version:

– Highly absorbent dyes can be used that can even capture sunlight in ultra-thin layers. Crystalline silicon, on the other hand, is not as good as absorbing light as well and therefore needs a thicker layer – in other words: more material – same effect.
– Some dyes can capture near infra-red or UV light and allow visible light to pass through, which makes it possible to have transparent solar cells.
– Many of the dyes have been in existence for decades and are cheap to manufacture.
– The cells can be mass-produced using the "roll to roll" method, which will make production even cheaper.

"One gramme of dye is sufficient for ten square metres of solar cell". Frank Nüesch drizzles a solution of cyanin dye onto a special fabric containing fine conductor tracks. These components are destined for the production of low-cost solar cells in the future.

An old-fashioned dye

Empa researcher Nüesch is one of the pioneers of the field – he obtained his doctorate in the 1990's in the team run by Michael Grätzel, who invented dye solar cells, which is a related technology. It is hardly surprising that he has remained faithful to this subject in spite of having quite a few other research projects. In order to significantly reduce the cost of solar energy, Nüesch uses a cheap dye. The group of cyanine dyes had already been discovered in the 19th century, and was used as a sensitiser in black and white photography from the beginning of the 20th century. The dyes captured red lightof low energy and were able to reduce silver salt in the strips of film. The first highly photosensitive films had arrived. The dye is still manufactured industrially today, and is used for storing data on CD-ROMs and for biomarkers – soon it will also be possible to use it as a low-cost raw material in organic solar cells.

Frank Nüesch drizzles a little of the dye solution onto a conductive fabric that will later be used in his solar cells, and enthuses: "These photo dyes are the most powerful light absorbers in existence." Ten square metres of solar cell can be coated with just a single gramme of dye. He smiles. "However, it's plain to see from the researchers' aprons whether anyone has spilled any".

Completely airtight - the "TREASORES" project

However, there is more to it than just the well-known dye. Organic solar cells consist of several layers: First, doped polythiophene (an electrically conductive polymer) is applied to a pane of glass with an electrically conductive tin-oxide coating. This is followed by the cyanine dye, then a layer of C60 carbon. A layer of aluminium hydroxyquinoline makes the connection to the counter electrode, which consists of vacuum-metallized aluminium. The problem is: Everything has to be completely airtight so that the dye and the organic helper layers are not destroyed by oxidation.

An important research topic on the road to organic solar cells is therefore the search for suitable electrode materials that seal the system at the same time. Nüesch is also active in this field as the coordinator of the European "TREASORES" project ("Transparent Electrodes for Large Area, Large Scale Production of Organic Optoelectronic Devices"). Together with 13 partners from European universities and companies, a flexible electrode material is being looked for that replaces the rigid tin oxide-coated glass panels. The top electrode made from aluminium is also ready for delivery. The EU-funded project started in November 2012 and will run for three years. Upon completion of the project, the plan is to have a system of electrodes and dense layers that will ensure that the organic solar cells have a long service life and can also be mass-produced quickly and at low cost on large industrial machinery. //

1

Drive CLEVER with natural gas and electricity

Empa has played a major part in the development of natural gas cars that are suitable for everyday use. Now comes the next chapter – the CLEVER natural gas hybrid car. The test vehicle has just driven its first few laps with EmpaNews sitting at the helm.

TEXT: Rainer Klose / PICTURES: Empa

2

3

1
The CLEVER on its first drive on the Empa campus. The exterior of the VW Touran is unchanged.

2
The 4.5 kWh battery is accommodated in the luggage compartment. The module originates from ETH Zürich and has already proven itself in the "Formula Student" race series. Empa developed the power electronics.

3
The heart of the hybrid drive is the electric motor, which sits in front of the rear axle in the underbody.

4
An additional display on the dashboard provides the driver with information and gear changing advice.

From the outside the vehicle looks like a normal 2007 model of the VW Touran. But lurking under the bonnet is a revolution – a drive concept that has never been seen before and is now being researched and developed at Empa. It's a sunny September afternoon, and the CLEVER, the world's first natural gas full hybrid vehicle with manual transmission, is ready for its maiden test drive at the Empa Motorenhaus.

Initially the vehicle is still sits on the roller dynamometer, on which the fine tuning of the drive systems takes place. Before the journey commences, project leader Patrik Soltic explains how the project arose, and what the vehicle can do: Empa has been researching natural gas engines for several years. One of the world's first natural gas turbo cars was created on the Dübendorf premises, where combustion methods were researched that made it possible to start an engine directly by using natural gas – without petrol as a starting aid. The technology, developed at Empa, has now been on the road for quite some time: economical, reliable and powerful natural gas turbo engines are available today from VW, Opel and Fiat.

Saving money

Empa is now taking things further: "A natural gas hybrid powertrain would make a medium class vehicle about 20 percent more expensive – but it would save up to 45 percent CO_2" explains Soltic. "This potential of saving greenhouse gas emissions could be extremely interesting, particularly to fleet operators." Professional car buyers are not just interested in the purchase price of the vehicle, but also in the "Total Cost of Ownership" (TCO) – the overall costs over the entire service life of the vehicle.

Rather than just running through the entire model theoretically, Empa decided to build a real vehicle that could be tested in the field. At the same time, Soltic's team developed new concepts for more efficient natural gas combustion on the engine test benches at Empa. The ETH Zurich also is involved as a partner: the research group managed by Konstantinos Boulouchos researches the basics of combustion processes by simulating the flow and combustion behaviour of fuels in the cylinder on the compute. The research group managed by Lino Guzzella provides the theoretical basics for controlling the hybrid control systems and the dimensioning of the components. Industrial partners Volkswagen and Bosch aditionally provide series production technology in order to ensure that the

CLEVER test car can be put on its wheels. But Empa researcher Soltic likes to emphasise: “The idea of a natural gas hybrid with manual gear changes is not one of the company strategies of our industrial partners”. “However, I am certain that they will be taking a close look at our results”, he says.

A “stripped” VW Touran

The beginnings of the CLEVER project go back to the year 2007. The goal was to combine a hybrid system with a natural gas combustion engine. However, the 2008 car crisis put the stoppers on everything: many suppliers ended up in difficulties, and agreements were broken. This meant that special pistons for the engine could not be delivered. The project ground to a halt. However, the delay also had some advantages: In 2009 some automotive components that had been specially designed for Hybrid vehicles suddenly became available that did not previously exist.

Finally the Touran on which the CLEVER is based could be stripped and reconstructed at Empa. Its conventional 1.6 litre engine ended up on the shelf, and a 1.4 litre natural gas turbo engine was installed under the bonnet. Another series-produced component from VW provides the power-coupling of the electric engine and the petrol engine: the all-wheel-drive gearbox of a VW Tiguan. The drive shaft, which leads from the gearbox towards the rear and normally drives the rear axle, is simply used in the opposite direction: The electric motor drives this shaft and therefore transmits its power to the gearbox and finally to the front wheels.

Battery technology from ETH

Now a suitable battery was needed. Patrik Soltic relied on a development by ETH students, who had created an appropriately powerful basic system for the “Formula Hybrid” student race series. The tried and tested battery-module was equipped with new electronics and now occupies the former luggage compartment of the CLEVER. The battery capacity of 4.5 kWh “is more than adequate for our purposes”, says Soltic. Nor does the power consumption of the 30 kW electric motor cause any problems – the component copes with up to 100 kW during a “Formula Hybrid” race.

Soltic has now detached the CLEVER from the roller dynamometer and pushes it out of the engine building. Now EmpaNews can get behind the steering wheel. Over the first few metres the car feels like any series-produced VW; The interior and the controls of the Touran are unchanged. The six-gear transmission also operates as usual. The first thing that you notice is the monitor in the middle of the dashboard. This is where the CLEVER gives the driver recommendations for gear changes and shows whether the drivetrain would work more energy efficient in the next gear up or down.

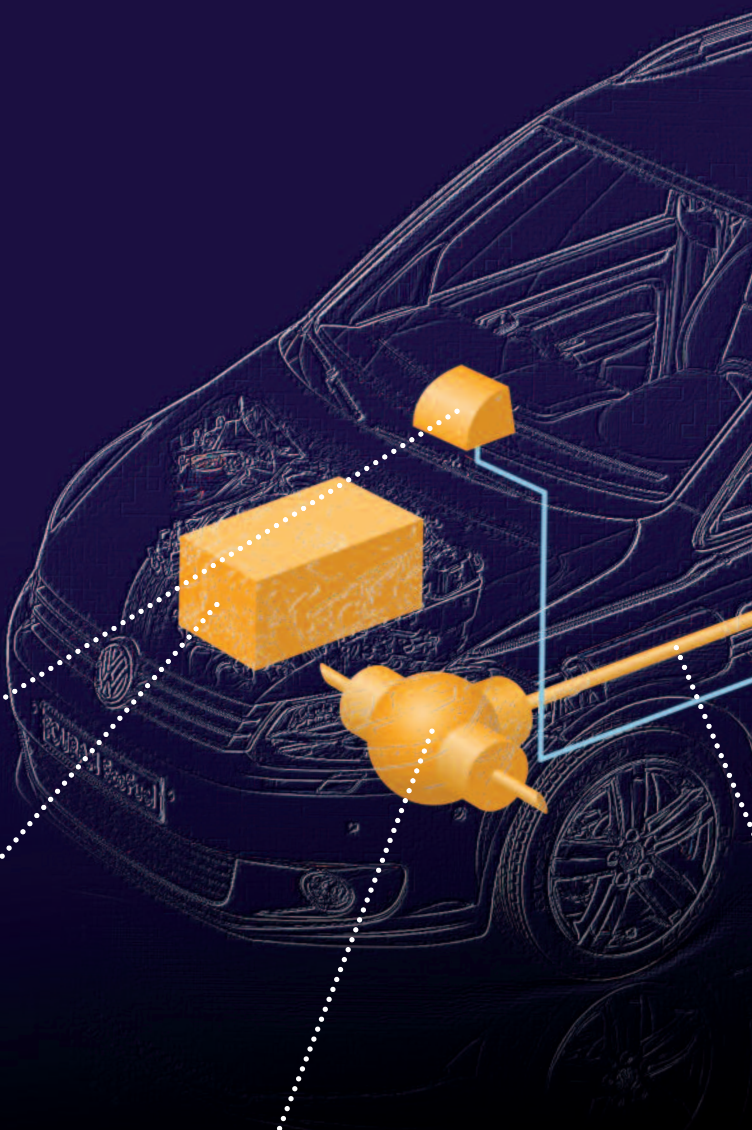
Smart driving with the CLEVER

When the car rolls up to the first red light, Soltic gives the first driving advice: “Put it in neutral and roll up to the traffic light just with slight pressure on the accelerator”. This is where the hybrid shows its strengths: Instead of letting the engine run inefficiently in the partial load range, it is shut off by the on-board electronics. The electric motor provides propulsion until the car stops at the traffic light. Once it arrives there the combustion engine stops until the driver presses the clutch and selects first gear again.

It takes a bit of getting used to before you comprehend the philosophy of the car and adapt to the actual driving style. In certain situations it is worth driving the CLEVER using the electric motor only – to do this the gearbox must be in neutral and the thrust of the electric motor is controlled using the accelerator. The electric motor also is active if a gear has been selected. It either provides additional power and saves fuel, or it obtains power from the transmission and charges the battery. The on-board computer selects the operating modes in such a way that the natural gas engine always operates in the most energy-efficient range and the battery has a balanced charge situation. Hence the car is completely autonomous and never needs to be plugged into a socket.

“Of course, we simulated all of this on the computer first. We would not have needed a real car to work out the potential and the operating strategy“, says Soltic. However, during test drives in a real car you can evaluate many fine details such as driveability and acoustics better than in a computer animation. And that would be the true sense of the CLEVER: Thenatural gas hybrid should not just help to do research on new technology, but also show whether normal people without a degree in engineering can cope with it. “Empa is the link between research and practical use”, says Soltic. “The CLEVER is a good example of this. We want to use it to bridge a knowledge gap in the alternative drives area”. //

A CLEVER technology – the

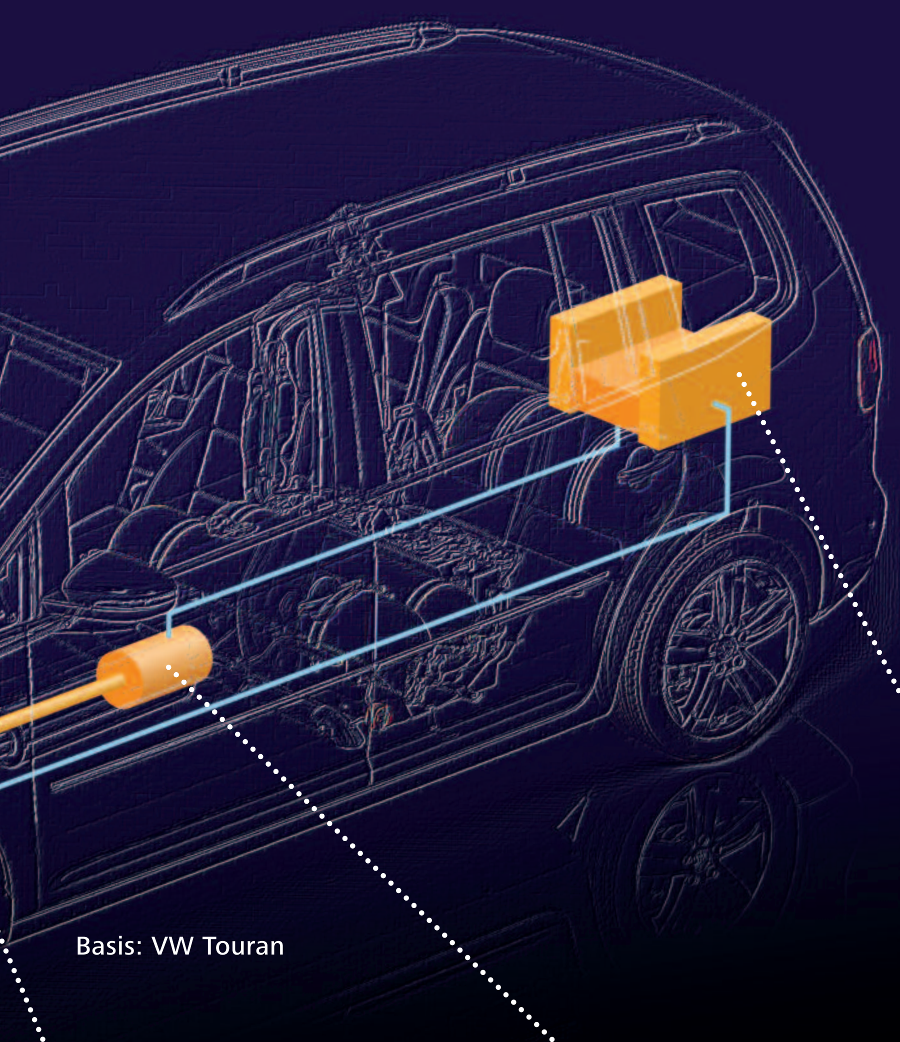


Display for monitoring the driving status.

1.4 litre natural gas turbo engine from VW, output 110 kW.

Manual gearbox from VW Tiguan, four-wheel drive version.

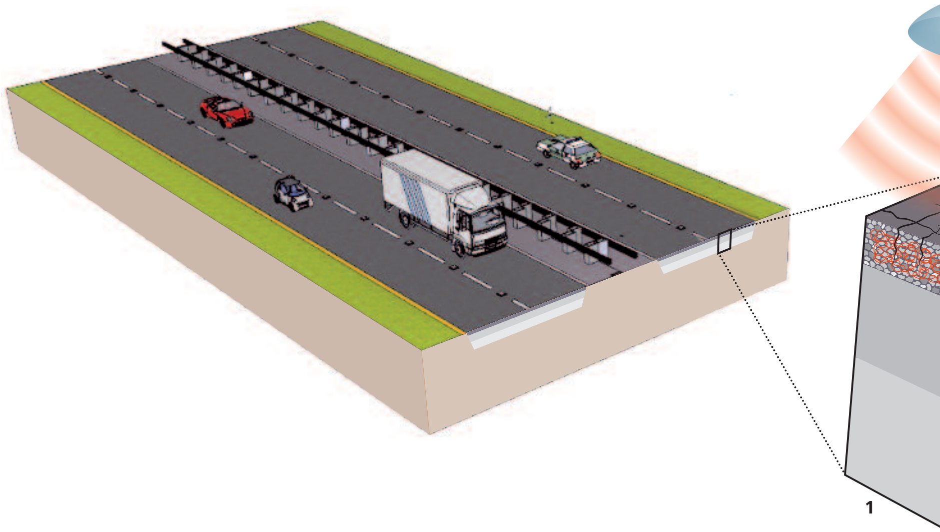
Hybrid drive under the X-ray



Drive shaft – normally leads to a driven rear axle. However, it is used "in the opposite direction" in the Empa hybrid: in this case the electric motor feeds energy into the drive.

Electric motor, output of 30 kW.

Electric storage consisting of Li-ion batteries, inverter and power electronics.

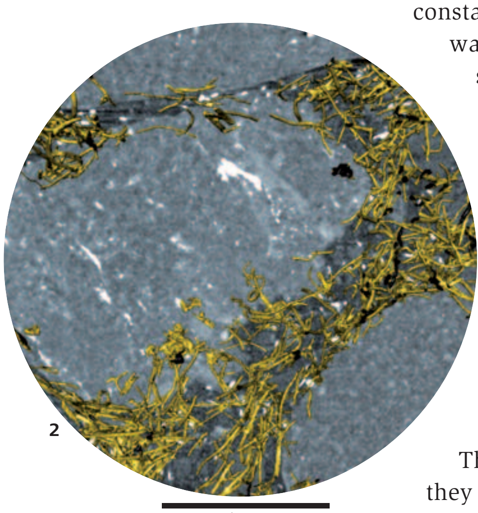


Brought to the boil and freshened up

The surface of a Swiss road has to be replaced every 15 to 20 years. The road works often lead to traffic jams. Empa researchers are working on a new surface, which can not only be repaired without causing traffic jams, but is also considerably more durable.

TEXT: Marco Peter / PICTURES: Empa

A road doesn't have it easy: Temperature differences and aggressive chemical substances such as oxygen in the atmosphere and road salt attack the road surface and make it brittle. Sooner or later, microscopic cracks will develop under the constant pressure of pulsating traffic. The road is penetrated by water, which freezes in winter and makes the crack bigger, since water expands by up to ten percent when frozen. "As soon as the crack is visible to the naked eye, it's already too late", explains Alvaro Garcia from Empa's laboratory "Road Engineering/Sealing Components". Different repair techniques are practically used at present. For example, visible cracks are filled in and sealed so that no more water can enter. These repaired areas are clearly visible – they show a thin black line of tar on the surface. However, eventually there will be no other alternative but to replace the entire top layer.



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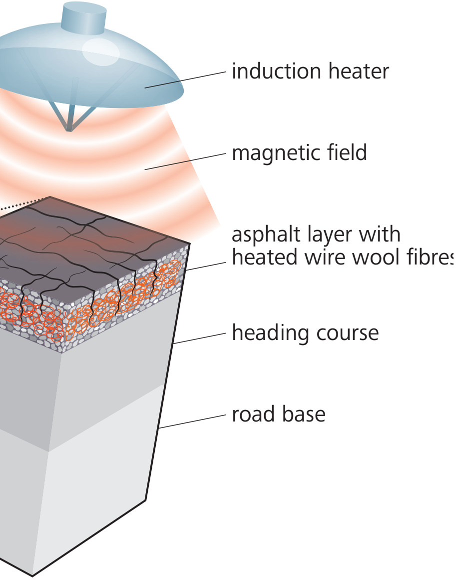
A Swiss motorway consists of an asphalt base layer, a binder layer and a top layer. Thanks to extremely fine wire wool fibres in the top layer, it can be heated by means of induction, and small cracks simply "melt together" again.

2
The microscope picture shows homogeneous distribution of the gold-coloured wire wool fibres in the bitumen that surrounds the gravel.

3
The road tester will tackle the new asphalt in the final project phase to test its repair capability.

Seal up cracks while they are still "fresh"

Then Garcia had an idea. Why not close the cracks while they are still microscopic? He wanted to make use of the characteristic that the bitumen in asphalt is viscous when doing this. Bitumen, a complex mix of long-chain hydrocarbons that is created during the vacuum distillation of crude oil, is pitch black and functions like glue: It sticks stones and sand to asphalt. Garcia mixes this adhesive with extremely fine wire wool fibres. Now, when the first micro-cracks appear in the new surface, the maintenance team moves in with an induction heater. Just like the induction cooker in the domestic kitchen, this device creates elec-



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tromagnetically induced alternating currents, which are converted into heat in the metal fibres. The wire wool becomes hot and heats up the surrounding bitumen. At 80 degrees Celsius the asphalt starts to "melt" and solidifies again when it cools inside. The surface has (almost) repaired itself.

Before Alvaro Garcia started to concentrate on Swiss asphalt, he tested these methods on streets in the Netherlands together with colleagues from DELFT technical university. 300 metres of motorway were provided with the new asphalt near Vlissingen, in the south west of the country. The traffic has now been travelling over this test section for two years. When after 12 to 13 years the surface layer reaches the end of its service life, the scientists want to move in with the induction heater and "refresh" the surface. Streets in the Netherlands consist of porous asphalt, known as OPA. In this asphalt the gravel stones are only held together by a little bitumen and the asphalt is permeated by a network of pores, so that water can seep into it and run off at the sides of the road surface. In Switzerland, on the other hand the stones are completely enclosed by bitumen and no water can enter.

Due to these different types of asphalt, Garcia and Ph. D. student José Norambuena cannot simply copy the results of the Dutch project and apply them here. Instead they must work in the lab using the "trial and error" principle. "The correct asphalt mixture for Switzerland still needs to be discovered", says Garcia.

It's a case of having the right mixture

At Empa there is a mixer which looks like a dough mixing machine in a large bakery. The two scientists mix asphalt samples in this device at 160 degrees Celsius – they add stones, sand, bitumen and wire wool fibres in varying order. They also test different aggregates and the wire wool fibre sizes. So far, they have had the best results with thicker, shorter fibres because these were distributed better in the bitumen after mixing, and no clumps were formed. In this case, thicker means a diameter of about 3 micrometres and short means a length of one to 3 millimetres.

The researchers then press the different asphalt mixtures into test blocks that are about the size of a letter. These samples are then broken up in the laboratory using a machine, and the measured pressure is recorded. The laboratory sample is then melted down under the induction heater, and put it into the breaking machine again. The force that is needed to break the sample again gives the scientists an indication of the level of "healing" in the asphalt mixture. This cycle is repeated several times.

Garcia wants to have worked out the optimum asphalt composition by next summer. He will then use it to asphalt a section of road, but not a section that will be actually driven over. Instead he is going to subject the new surface to heavy use with the Empa road tester and therefore simulate the traffic load over a 10 to 15 year period. This device, which was developed by Empa and the University of Stellenbosch in South Africa, looks like an oversize, orange horse box trailer and has several "load wheels" inside which are continuously driven over the surface and therefore simulate the load. The metal fibres in the asphalt are heated after the endurance test and the surface melted "into shape" again. This should allow it to withstand the daily deluge of vehicles for another five to six years. //

“Empa never stands still”

Brigitte Buchmann has been a board member at Empa and head of the “Energy, Mobility and Environment” department since 1st September 2012. Where did she come from? Where does she want to go? What are her goals? EmpaNews wanted to know.

TEXT: Rainer Klose / PICTURES: Empa

On a personal note…

Brigitte Buchmann studied chemistry at the University of Zurich, and gained her Ph.D. in 1988 on the subject of organometallic chemistry. She has worked at Empe since 1989. In 2002 the researcher took over the management of the "Air Pollution / Environment Technology" laboratory and was the first person to use comprehensive satellite data to investigate air quality in Switzerland. She is a member of the Federal Commission for Space Affairs, a Swiss ESA delegate and has been the head of the World Calibration Centre for Ozone in the "Global Atmosphere Watch Program" (GAW) of the World Meteorological Organisation (WMO).

You have been head of the "Energy, Mobility and Environment" department since September – and therefore an Empa board member. How long have you been aware that these duties were coming your way?

It was last summer when our director Gian Luca Bona asked me whether I would like to take over the department from my predecessor Peter Hofer. In the autumn I decided to accept this new challenge. The ETH council appointed me as a board member at the beginning of December, 2011.

You have known the department and your work environment for a few years now, correct?

Yes, I have been in the department since December 1989. For the first ten years I managed a group in the "Air Pollution/Environment Technology" department, and subsequently managed the department myself for another ten years.

How have your responsibilities changed during this period?

First of all, it's important to know that Empa has undergone some significant changes during this time. For this reason alone, my everyday work has changed significantly at all levels. During this time, we have expanded our activities from national research programs to international cooperation work. As the head of department I have travelled the route that has taken us from merely measuring data to modelling. This has allowed us to improve the quality of our scientific statements considerably. Something is always being redesigned, readjusted or reorganised. Empa has never stood still since I joined the organisation.

You have your own specialist area well under control. Now there are additional laboratories to look after. What do you find easier: just looking after your own "patch", or thinking your way into new fields?

Both are interesting. I have had knowledge of many specialist areas for a considerable time because I have been on the steering committee of the main Empa research area of "Natural Resources and Pollutants" for quite a while. This has allowed me to get to know many colleagues and their research fields much better. We were already working on joint projects with some departments.

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Personally, I have never specialised in any particular research area during my scientific career, since I enjoy looking at different areas of chemistry.

Can you give me an example?

This was also the case during my PhD in Chemistry. I worked with organometallics – which requires both in-depth understanding of organic synthesis and good knowledge of substances in inorganic chemistry.

How much of your new department have you seen?

I have already visited several departments and had meetings with the research groups, such as in the engine building, the analytical chemistry department and the "Solid State Chemistry and Catalysis" department. I appreciate the personal exchange of information about new projects, which provides me with more inspiration for ideas than just reading project reports and research proposals.

"You can't stand still – you have to acquire new knowledge and build on it. These processes can not be planned years in advance"

What do you consider the future challenges to be? How to you want to organise the department?

We are working on a series of socially important tasks in our department, which will require a lot of attention in the near future, but will also attract attention. Many topics are associated with the energy usage area: We are looking for new materials and approaches with which energy efficiency can be improved (in the mobility area, for example) and make a major contribution to our energy consumption. At present we are building the "Mobility Demonstrator", which is an extremely large project. With this we want to take the development of different types of mobility such as hydrogen-powered fuel cell vehicles, gas-powered vehicles and electric-powered vehicles further, and test them in the field. Our goal is to put all future mobility onto a sustainable basis that also suits our everyday needs. The Mobility Demonstrator is a research and technology transfer platform into which new results from Empa research will be repeatedly integrated.

With topics that are so socially and politically important, I assume that many politicians from the government and the cantons ask you for advice. Do you feel such a thirst for knowledge?

There has actually been a great deal of interest, and our heads of department are also extremely well-versed in the politics, such as Christian Bach on the subject of mobility, Andreas Züttel in the area of hydrogen technology and Anke Weidenkaff, who researches into materials for fuel cells, among other things.

Your department's title is "Mobility, Energy and Environment". What's happening on the environment front?

The laboratory that I have managed for the last ten years deals with the topic of the environment. One area that the lab concentrates on is the investigation of anthropological emissions (i.e. emissions caused by human beings). Here we use and develop new model approaches and also highly specialised measuring devices. In the different labs, we also analyse the effect that new materials and technologies have on the environment by means of so-called lifecycle analyses or eco-balances, for example. On the resource front we examine raw materials that are rare or in short supply such as indium and gallium, and attempt to find out which elements can replace them in order to avoid a technological bottleneck in a few years that could significantly hamper economic development.

Previously we spoke about the "Mobility Demonstrator", which is continuously adapted to the latest knowledge and reconfigured. Does this not also apply to your entire department? Have you taken over a permanent building site?

Permanent building site sounds too negative. But it is true that you have to continuously re-orientate yourself in research. You can't stand still – you have to acquire new knowledge and build on it. Of course, these processes can not be planned years in advance – and certain developments can also have an effect on the orientation of individual departments. We therefore have to remain flexible, which lies in the nature of our research activities. The one thing that remains unchanged is our goal: We want to be a competent partner for innovations to industry and the public sector thanks to our skills and our successes in practical implementation. //

Olympic Honours for Tensairity Technology

It was a massive stage for the Tensairity technology developed at Empa: 14 metre long, feather-light Tensairity elements floated high above the heads of around 80 000 spectators at the closing ceremony of the Paralympics on 9th September in the Olympic stadium in London. The three crescent-shaped airborne elements emulated the “Agitos” - the symbol of the Paralympics.

The organisers of the Olympic opening and closing celebrations turned to Rolf Luchsinger and Roland Verheul from the “Centre for Synergetic Structures” during their search for the top balloon or kite experts, with an extremely specialised "wish list" in their pocket: they were dreaming of balloon-like elements with geometrically sophisticated designs that were extremely light and could be inflated within minutes. The solution presented by the Empa researchers consisted of made-to-measure Tensairity elements that had originally been developed for lightweight construction of roofing or bridges, for example. The elements, consisting of a membrane, rods, cables, and air, are currently also being used as oversize kites, and are destined to be used as airborne wind energy plants at an altitude of up to 1000 metres in the future.

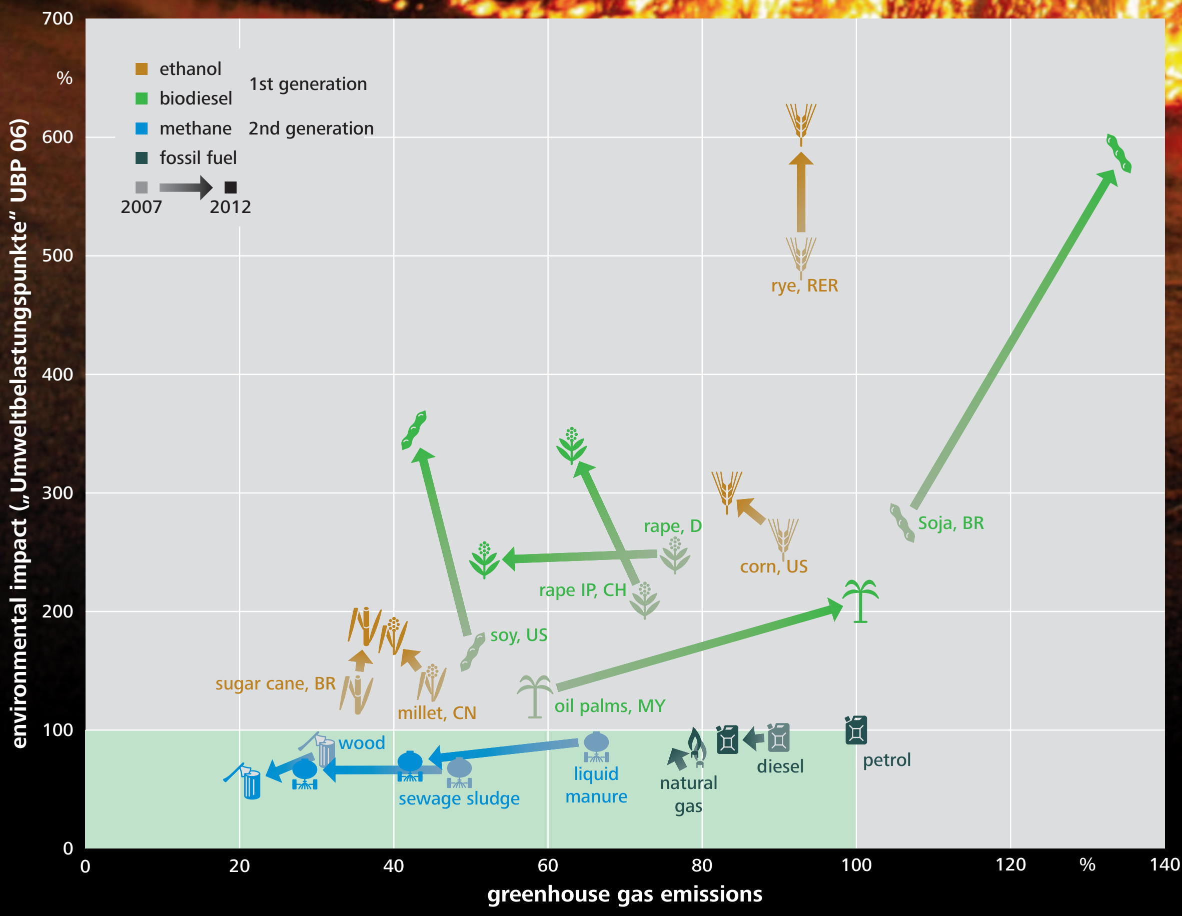
Closing Ceremony of the London 2012 Paralympic Games on Youtube: *http://youtu.be/pIRHMmM2z7c*

“Swiss Kite Power” project: *www.swisskitepower.ch*

Biofuels: what do you mean, “green”?

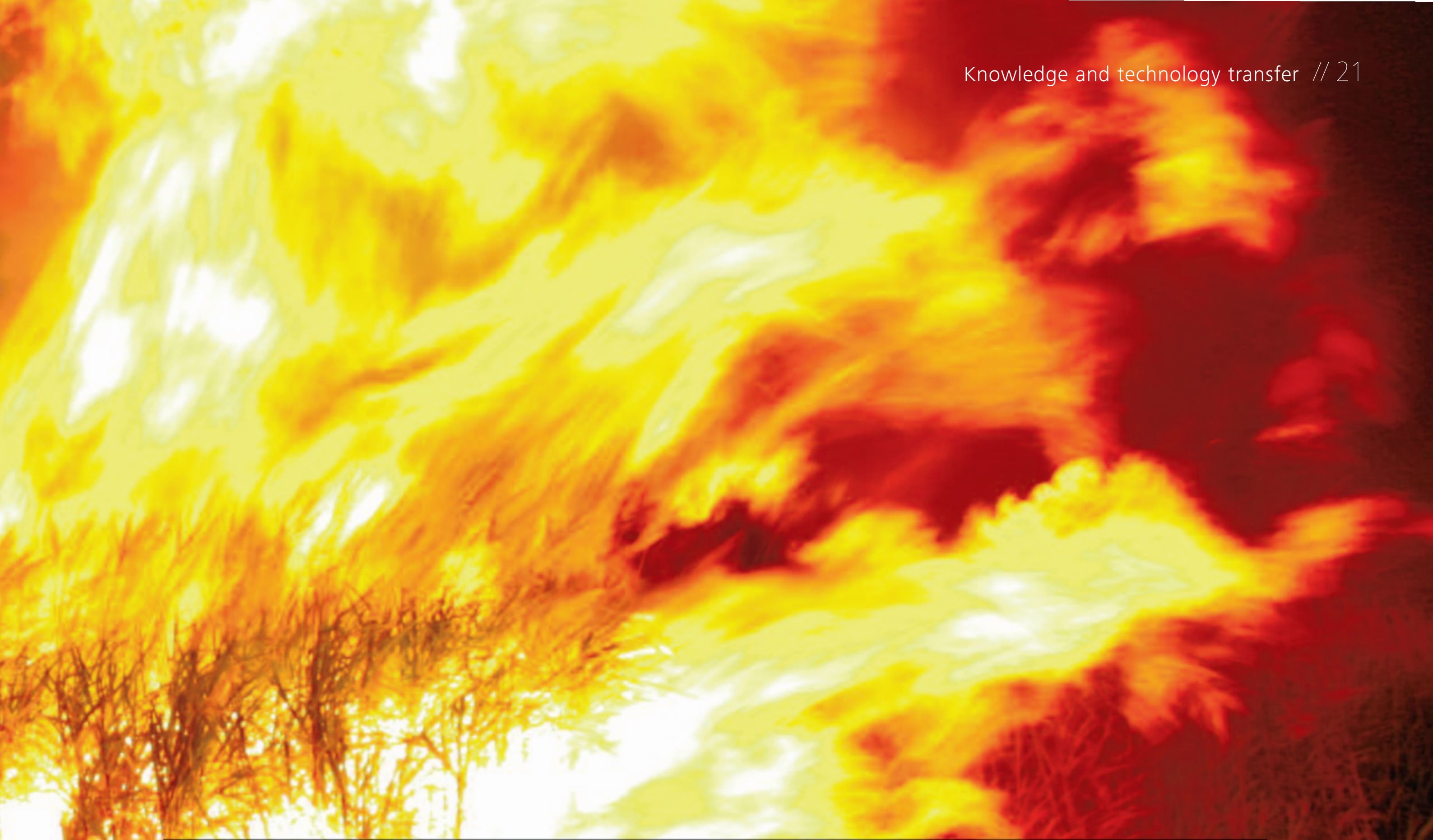
From hero to zero. This is how the history of biofuels can be summarised. A new study by Empa analysed the eco-balance of different biofuels and their production processes. Overall, some of them are only slightly more environmentally friendly than petrol.

TEXT: Michael Hagmann / PICTURE: Wikimedia.org / ILLUSTRATION: Empa



Bio-fuels are being acquired from different sources all over the world, with varying environmental impact and greenhouse gas emissions. The arrows in the diagram show the result of recent environmental calculations in comparison to calculations from 2007. The results for bio-fuels made from grain and soya are particularly poor – even in comparison to petrol, which is made from crude oil.

Background picture: burning sugar cane field during the harvest in Australia.



Over the last few years, there has been a significant increase in the demand for supposedly environmentally friendly bio-fuels worldwide; this resulted in an increase in the cultivation of so-called “energy plants”. At the same time, eco-balance experts have refined and further developed methods for carrying out environmental assessments of bio-fuels. Since bio-fuels mainly consist of agricultural products, it is argued whether the production of bio-fuels is justifiable from an ecological point of view, or whether there is a preponderance of negative effects, e.g. on the supply of food or the eutrophication of usable soil.

In order to answer this question, on behalf of the Swiss Federal Office of Energy (SFOE), and in collaboration with the ART agricultural research institute and the Paul Scherrer Institute (PSI), Empa analysed the environmental balance of numerous bio-fuels, including their production chains. In comparison to the world's first eco-balance study of its kind from 2007, which was also carried out by Empa – the team, led by Rainer Zah, included new energy plants and manufacturing processes, and also updated the evaluation method.

Fewer greenhouse gasses – but other burdens on the environment

Despite having considerably more data and “state of the art” methods, the latest study reached the same conclusion: Bio-fuels from agricultural processes may help to reduce the emission of greenhouse gases and “ozone killers”, but they cause other damage to the environment such as over-acidified and over-fertilised soils and smog. “The majority of bio-fuels therefore relocate the burdens on the environment: fewer greenhouse gasses, but more cultivation-related damage”, says Zah. For this reason, only a few bio-fuels have a better overall eco-balance than petrol. The most environmentally-friendly is bio-gas from residual or waste materials, which pollutes the environment by up to a third less than petrol. depending on the starting material. Among the bio-fuels, Ethanol-based fuels have tended to have a better eco-balance than oil-based fuels; however, to a great extent the result depends on the individual production method and technology.

New understanding of the greenhouse gas balance of bio-fuels

The new calculation method allowed Zah and his colleagues to remedy the “weaknesses” of the previous study. The 2007 researchers underestimated the effects of the conversion of natural areas, such as the clearing of rainforest, on the greenhouse gas balance. The latest study reveals that bio-fuels from cleared areas usually produce more greenhouse gas than fossil fuels. This also occurs with indirect land conversion: If existing farmland is used for the production of bio-fuels, woodland must be cleared in order to maintain the previous levels of food and/or fodder production

On the other hand, positive effects can be achieved if the cultivation of energy plants increases the carbon content of the soil, e.g. by planting oil palms on unused grasslands in Columbia, or jatropha plantations in India and East Africa, where desolate land has been made arable again. “In spite of this, you cannot generally regard jatropha as a 'wonder plant', because its eco-balance primarily depends on local agricultural practice and the previous use of the land,” says Zah. His conclusion: Every new bio-fuel needs to be scrutinised exactly and individually. //

Silence behind drawn curtains

In many areas, noise is a major disruption that needs to be dealt with. Together with industrial partner Weisbrod-Zürrer AG and textile designer Annette Douglas, Empa researchers developed a new fabric for making curtains that are light but noise-absorbent. The new textiles absorb five times more noise than conventional translucent curtains. The only thing that "new" and "old" have in common is the translucency of the materials. The curtains are ideal for offices, conference rooms and also restaurants.

Having won a total of four awards, the noise-absorbent curtains are now available on the market. Global sales of the collection are being dealt with by Vescom, and the Sangetsu company will also be distributing the collection in Japan.

Sales in Switzerland will be dealt with personally by designer Annette Douglas. More information about the three different curtain materials and the designer can be found on the web site at *www.douglas-textiles.ch*. //

Alles schon drin!

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